JULY 31, 1989

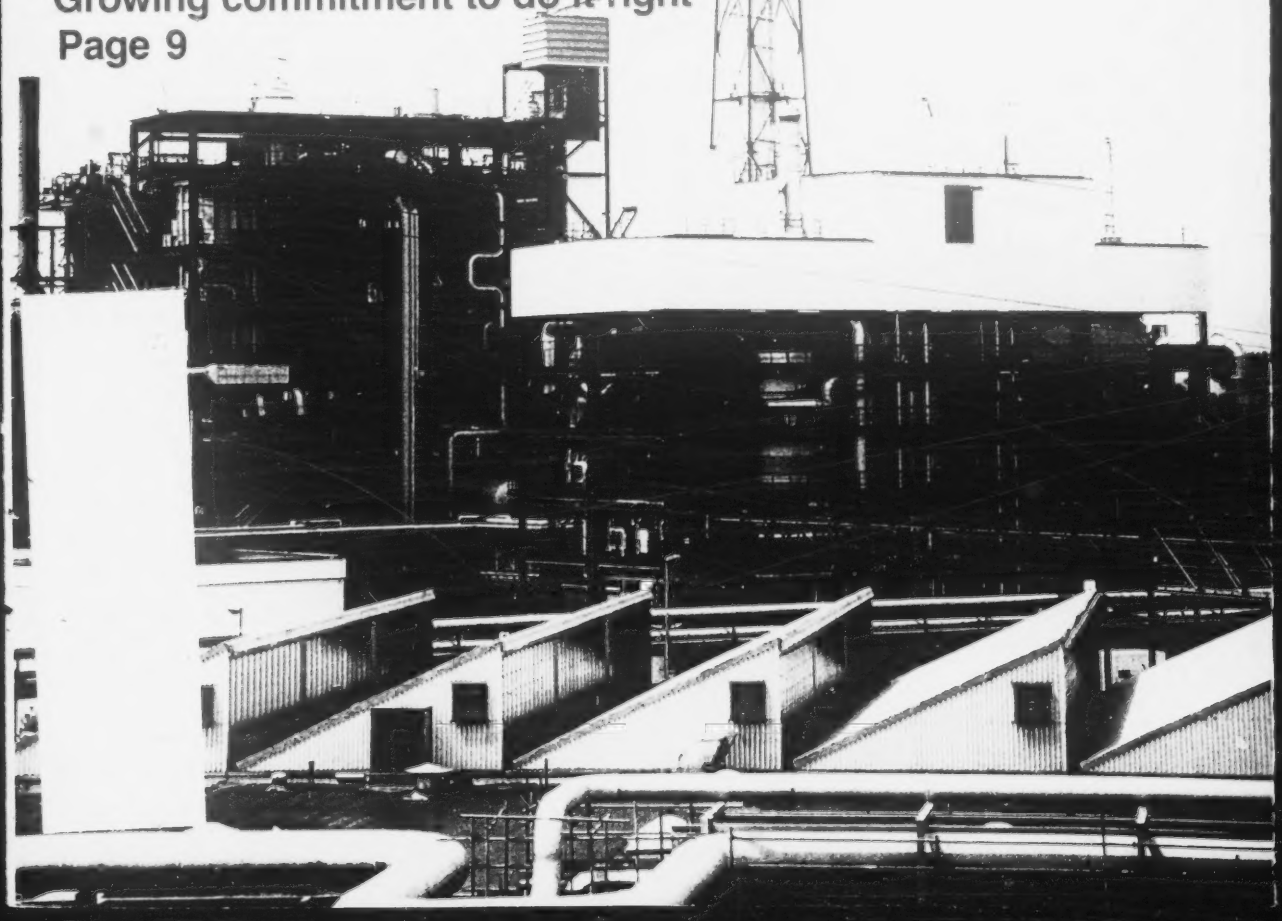
CHEMICAL & ENGINEERING

NEWS

Hazardous Waste Management

Growing commitment to do it right

Page 9



CHEMICAL & ENGINEERING
NEWS
JULY 31, 1989

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Cover: Bayer's hazardous waste incinerator at Leverkusen, West Germany. Photo by C&EN's David J. Hanson

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LETTERS

Women in chemical sciences

SIR: While browsing through the June 5 issue of C&EN, I was struck by an apparent paradox concerning two different items. The first was in the ACS News section (page 27). The Women Chemists Committee reported on a well-attended symposium entitled, "What ACS and Its Members Can Do To Encourage Women in Chemistry."

The second item (page 18) was the report of the 20 U.S. finalists for the International Chemistry Olympiad—not one of which is female. Although the short article did not explain how the finalists were chosen, it mentioned that the final 20 came from a group of 700 outstanding high school students. It is hard to imagine that there was not a single young female chemist among the 700 students who was competitive with the 20 plus 4 alternates chosen.

Since decisions made by committees—such as the local selection committees in this case—are always based on at least somewhat subjective information, a bit of sensitivity to the low representation of women in chemistry could have helped to identify appropriate candidates. Indeed, one wonders whether there were any women on the selection committees. If ACS and its members are serious about encouraging women in chemistry, they should do so at all levels, from the youngest students through professional chemists.

Clearly, an opportunity to do just that was neglected in the selection process for the Olympiad participants. Although this affects only a small number of people, it is symptomatic of the larger problem of getting and keeping young women interested in careers in the chemical sciences.

Rachel E. Klevit
Assistant Professor
of Biochemistry
University of Washington

Nuclear power

SIR: If there is no future for nuclear power, as Harvey Wasserman proclaims (C&EN, June 5, page 3), then prepare for rationing. You may call it compulsory conservation if a euphemism is more palatable. The fact remains that we cannot meet even the relatively modest air quality goals proclaimed by President Bush and continue to generate unlimited electricity by burning fossil fuels.

I rather doubt that the nuclear power industry is the greatest managerial disaster in U.S. history. In any event, it has plenty of company. Just read the report on the Massachusetts Institute of Technology productivity panel that begins on page nine of the same issue. The U.S. seems to do very well in producing managerial disasters, if you choose to believe the MIT panel.

In the distant future, we will have new energy sources. But anyone who believes that sun, wind, tides, and (con) fusion will contribute significantly to our energy budget before the turn of the century also believes that the tooth fairy is about to begin neutralizing acid rain as he (or she?) flies from place to place every night.

J. M. Eby
Pennsville, N.J.

Funding undergraduate science

SIR: The article about Bassam Shakhashiri's excellent work in pushing for funding in science education (C&EN, June 5, page 12) raises many excellent points. In a very real sense, our role as a world leader in science and technology is at stake, and the only solution is more support at all levels for science, math, and engineering education.

One point that was not raised in the article was the lack of funding for the undergraduate colleges, which yield about half of all students who enter graduate school but have a very small part of the total science education budget. We in the undergraduate colleges struggle against long odds to support students in summer research activities and to maintain our own research viability. The majority of funding goes to support graduate institutions. I am not suggesting that we should not provide excellent graduate opportunities, but only that we must make sure that the foundations on which these graduate institutions rest, the major sources of their students, must also be well nurtured.

The major program established in the past few years for support of undergraduate research, the National Science Foundation Research Experiences for Undergraduates program, has gone almost exclusively to universities. At the same time, we struggle to support our undergraduates by begging money anywhere we can. We have more students, faculty resources, and equipment than we can support in the summer. This year we had students begging for the opportunity to do research with us who could not be accommodated. It is reaching the point where we find ourselves spending more time trying to get

Hazardous Waste Management: Planning To Avoid Future Problems

Waste generators as well as those who dispose of wastes strive to meet treatment and disposal rules responsibly, see reducing waste at source as key to these efforts; new service firms form to help solve problems

David J. Hanson, C&EN Washington

The complex web of laws and regulations spun in the U.S for the treatment and disposal of wastes has had several effects. Owners and operators of facilities that generate chemical wastes have become very concerned about their responsibilities to dispose of those wastes correctly, and a large industry has grown up to help solve their problems. Most recently, companies that generate waste not only are trying to handle it properly but are also trying to minimize the amounts of waste they generate.

The two principal federal laws that try to control hazardous wastes are the Resource Conservation & Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation & Liability Act (Superfund). Both are administered by the Environmental Protection Agency. RCRA is designed to ensure that hazardous chemicals are not discarded in such a way as to cause harm to human health or the environment. First passed in 1976 and strengthened by the Hazardous & Solid Waste Amendments of 1984, it provides for "cradle to grave" management of more than 450 chemical wastes listed in the law as hazardous. It requires specific permits for treatment, storage, or disposal of hazardous wastes and provides for a manifest-tracking system to ensure proper handling of currently generated wastes.

Superfund, on the other hand, provides for the cleanup of old waste sites—landfills, waste lagoons and ponds, and warehouses—where hazardous chemicals have been abandoned while still potentially dangerous. Nearly 90% of the more than $10 billion to be raised by 1991 for Superfund will come from taxes on basic chemicals. Currently EPA has a list of more than 1000 abandoned sites on its National Priority List. Either the government uses the fund to pay for cleaning these sites or it gets the companies responsible for the wastes to pay.

C&EN staff photo

Too many drums of hazardous waste are forcing industry to look for minimization methods

Although the two laws overlap in their regulation of hazardous wastes, it is RCRA that actually affects the most companies over the greatest period of time. EPA estimated in 1986 that more than 650,000 companies generated hazardous wastes in the U.S but that more than 99% of the waste volume came from 2% of those companies that are considered large-quantity generators.

In the past year, manufacturers generated more than 290 million tons of hazardous waste regulated under RCRA. Less than 5% was solid waste, the rest was wastewater. Industry is well aware of the volume of waste and of the high costs of trying to comply with the laws. As a result, many companies are making major efforts, often begun years ago but taking on new life in recent years, to try to reduce that amount of waste.

RCRA is a complex law, made more so by the 1984

amendments. Congress will again be taking up reauthorization of RCRA, probably not seriously until next year, but almost five years after passage a number of issues that still need to be settled are coming to the fore.

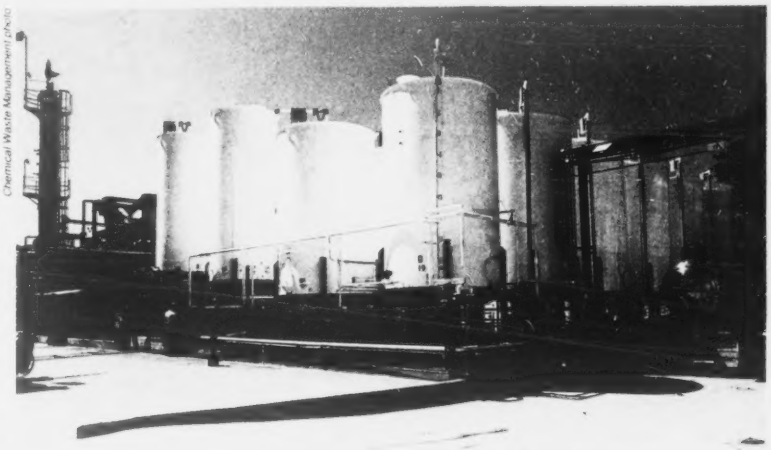
One of these issues has been the impact of the so-called land-ban rules. Congress listed land-disposal deadlines for specific wastes it considered hazardous and ordered EPA to ban the land disposal of any of these after their deadlines unless the wastes have first been made nonhazardous. These materials include "dioxins," certain organic solvents, a group of various chemicals called the California List, and a long list of industry waste streams. One of the main reasons for completely banning some wastes was to force companies to drastically reduce the volume of those chemicals or to stop generating them entirely.

Morton L. Mullins, director of regulatory affairs for Monsanto in Washington, D.C., says the land-ban rules proposed so far have resulted in some catch-22 situations for the chemical industry. "There are a number of situations," he says, "where you just can't do [the required treatment] or you simply can't afford to do it." The land bans have caused a lot of consternation just because they have been on such a fast track, Mullins adds. In the latest instance, the ban went into effect even before the final regulations appeared in the *Federal Register*.

EPA has to stipulate the extent of treatment these wastes must have before they can be put into landfills. The agency bases its recommendations on what it considers the best demonstrated available technology. Mullins believes that the recommendation of a performance level for treatment gives the industry a lot of leeway for improvement. "Once you've established that level of performance," he says, "then you are not only free but encouraged to go out and build a better mousetrap."

David Gramm, a legislative analyst for Dow Chemical, agrees that "when the land-ban regulations came out, a lot of companies got much more serious about waste reduction."

Joel Hirschhorn, senior analyst of waste issues at the Congressional Office of Technology Assessment, thinks EPA may have created the opposite effect. "Their approach in a sense freezes technologies where they are now by the kind of regulations they are putting out. They are telling people this is what you have to do with your waste with this kind of technology that is available now in the marketplace. From a technology development perspective, that's not a particularly good situation."



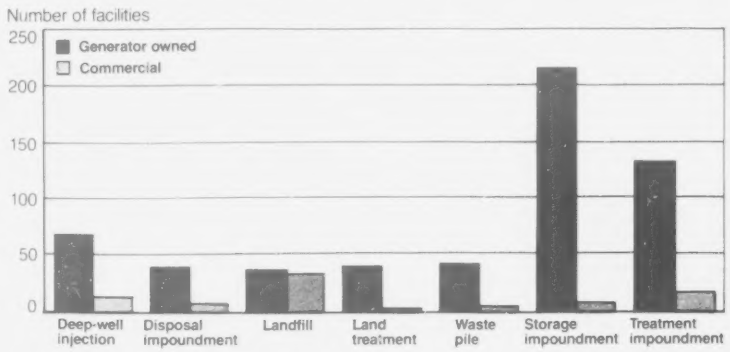
Chemical Waste Management photo

Solvent recovery tanks represent an easy way to reduce hazardous waste

The land ban on disposal of specific, listed wastes and waste streams is to be in full effect by May 8, 1990. Regulations for the first two thirds of the wastes that appear on the industry waste stream list have already been published and the regulations for the final third, mostly wastes that are difficult to treat, are likely to be proposed this fall. One of the problems with the land ban has been the need to give a number of the waste treatment programs two-year exemptions from full compliance because of the lack of treatment capacity.

Critics of the program believe the extra time will probably not lead to new ways of treating the waste, but just result in more use of landfills and incineration. Jeffery Denit, deputy director of EPA's Office of Solid Waste, says the program can only move forward at a pace that the nation's industrial infrastructure can handle. "One thing we need is some dramatic increases in technological innovations and cost efficiency for

Land disposal facilities owned by waste generators outnumber commercial operations



Note: Data were compiled for 320 facilities in 1986 and 1988. Some facilities have more than one process.
Source: Environmental Protection Agency

both treatment and minimization," he says.

The upcoming debate over RCRA reauthorization is likely to focus on an issue the nation has been reluctant to face. That is what to do about the high-volume, low-hazard waste that Congress has specifically exempted from RCRA's regulation. Such wastes include cement kiln dust, utility company ash and sludge, phosphate mining and beneficiation wastes, uranium and other mining wastes, and gas and oil drilling muds and oil production brines, and some chemical process wastes. The amount of unregulated waste is not known, but it is believed to be a much larger volume than the regulated wastes. In fact, various estimates inside and outside government put the amount of RCRA-regulated hazardous waste at just 10 to 50% of the total waste volume.

Thus, the definition of hazardous waste is going to be an issue, according to Richard Denison, a scientist with the Environmental Defense Fund. "In our view there are a number of large waste categories that are sort of falling through the cracks, resulting from the binary system we have for wastes—either your waste is hazardous waste and you have a panoply of controls or it is not hazardous waste and you don't have to do much of anything." Denison says that under the 1984 RCRA amendments EPA is supposed to be analyzing the status of these unregulated wastes and writing reports for Congress. That has not been done. "Because of this, EDF has recently filed a deadline lawsuit against the agency on a number of these and other deadlines that it has missed," he adds.

Mullins from Monsanto says the definition of hazardous waste is an issue about which the chemical industry is deeply concerned. "The Chemical Manufacturers Association has recently petitioned EPA for a rulemaking in the area of de minimis concentrations of hazardous constituents in waste," Mullins says. "A problem with RCRA as it now exists is that once a waste is generated there is no way to get it out of the system, no matter how much you treat it or how low the level of the hazardous component gets." CMA wants to create some sort of tiered regulatory system for hazardous waste based on the toxicity threat of the waste. "Our methods would be better served if we had some sort of continuum of control ranging from totally inert construction rubble at one end to, say, dioxins at the other," Mullins says. "We could have three or four management regimes in between."

Hirschhorn recalls that when OTA did its report for Congress on hazardous waste, one idea it promoted was a degree-of-hazard system, but Congress didn't buy it. EDF's Denison thinks that a tiered system for managing wastes has merit, but is concerned about how EPA would handle it. "The real problem that would arise is how you would implement such a system. The agency's meager resources devoted to enforcing the current system are not enough, and I think the whole problem would be exacerbated even more under that kind of proposal," he says.

A basis for discussing hazardous waste issues is the bill, S. 1113, introduced this year by Sen. Max S. Baucus (D.-Mont.). It is similar to a bill he proposed during the last session of Congress and has some provisions that worry industry observers. The biggest issue is the attempt to set statutory goals for waste reduction. Basically, the bill would require companies to certify that, for any process, less than 5% of the beginning material is ever released into the environment, either as emissions or waste.

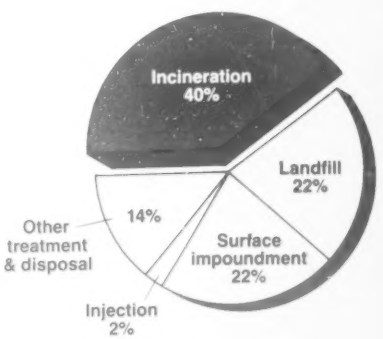
"In a lot of cases, this doesn't make any sense," says Mullins. "I think we will come out better without these kinds of arbitrary restraints." Denison agrees in part: "While the concept makes sense, where you set the numbers and how you measure the parameters is very difficult."

These ideas for streamlining RCRA may come to naught. The 101st Congress seems much more concerned about imposing stricter controls on municipal solid wastes than they are about hazardous wastes. "There is no sign right now that there will be any significant attention in this RCRA reauthorization to hazardous waste," opines Hirschhorn. "It's feasible that Congress could take a small action like asking for a study, but that might be all."

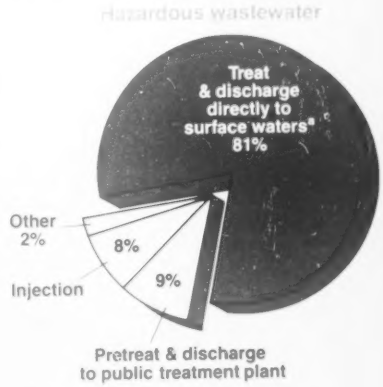
Even if Congress wanted to move on hazardous waste, its work would be impeded by a serious lack of comprehensive recent data. Except for some chemical industry data and estimates made by industry analysts, almost no studies have attempted to quantify the extent of the hazardous waste problem or determine what actually happens to those wastes. Since the 1984 reauthorization, when in-depth studies were done by OTA, EPA, and the Congressional Research Service, Congress has not asked for any further analysis of the issue.

This lack of data just adds more

Chemical industry relies on incineration for solids...



...treats wastewater on site before discharge


Hazardous wastewater
Treat & discharge directly to surface waters[a] 81%
Pretreat & discharge to public treatment plant 9%
Injection 8%
Other 2%

Note: Based on a survey of selected chemical plants
a Treated by plant with a National Pollution Discharge Elimination System permit
Source: Chemical Manufacturers Association

Europeans continue to use incineration on large scale to destroy hazardous wastes

As might be expected, the various nations of Europe are handling their individual waste problems in a variety of ways. An examination of the hazardous waste practices in two countries with large chemical industries—Switzerland and West Germany—and in one primarily agricultural country—Denmark—shows how approaches may vary.

There are some common threads. Incineration is the preferred method of destroying wastes, with the resulting slag or ash being placed in landfills. Incinerator capacity, however, is very tight, and usually leads to facility expansion, a solution that, in turn, generates environmental concerns.

Environmental regulation is a fairly recent phenomenon in Switzerland, which has a very active chemical industry. Its first major environmental law was passed in 1983 and environmental impact statements were not required until 1988.

In prior years Switzerland had a fairly bad reputation when it came to managing hazardous wastes and had had a number of serious episodes invclving leaking landfills. Today, according to Swiss environmental officials, most solid hazardous waste is incinerated and most liquid hazardous waste is used to fuel cement kilns. However, incinerator capacity is such that a lot of material is sent out of the country for disposal.

Thus, current plans call for four new regional incinerators for "special wastes"—a designation that covers, as it does in most countries, not only industrial chemical wastes but also some products found in municipal waste streams. Each incinerator would handle all the wastes generated in its specific region.

One incinerator is being built by Ciba-Geigy in Basel, and the problems facing this new facility demonstrate the growing concern Swiss citizens have about hazardous waste disposal. Much of this concern was sparked by the Seveso, Italy, accident in 1976 that sprayed 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) over the town. The concern was further fanned more recently by a fire in a chemical warehouse in Basel that resulted in toxic chemicals being washed into the Rhine River (C&EN, Nov. 9, 1987, page 16).

Ciba-Geigy already operates a rotary kiln incinerator at its Basel plant as well as a pilot plant that is testing new technology for the proposed incinerator. That new incinerator, however, was the subject of the first "public" hearing ever held in Switzerland on an environmental issue. The June hearing allowed all parties an opportunity to present their opinions about building the facility. The final decision on the incinerator will be made by the federal environmental office. That decision has not been announced yet, but the office is expected to approve the state-of-the-art incinerator.

Most of the opposition to the Ciba-Geigy incinerator, apparently, was not generated by concerns about the safety of emissions. Swiss law requires monitoring of nitrogen oxides, hydrogen chloride, hydrogen fluoride, oxygen, and particulates. (This is more than is required of U.S. incinerators.) Rather, opponents were concerned about the lack of incentives in Swiss law for companies to push for source reduction of the wastes, a practice the growing environmental movement in Switzerland believes is necessary.

In neighboring West Germany, the situation is, on the whole, similar. Incineration is the main method for destroying hazardous, or special, wastes. In the central state of Hessen, for example, there is one large solid-waste incinerator—located in Biebesheim and owned by the state government—that is designated to burn all the waste generated in Hessen that cannot be treated otherwise.

An incinerator has been operating in Biebesheim since 1917. The most recent one was built in the 1960s. Its two rotary kilns handle about 50 million tons of waste a year, but demand has exceeded capacity. Some wastes are now being buried underground in salt caverns and still more, about 100 million tons per year of mostly household waste, has to be sent to East Germany for disposal. So a third unit, which would nearly double the facility's total capacity, is being planned.

Officials of the facility, Hessische Industriemull (HIM) in Biebesheim, say there is growing public opposition to the expansion. Although the facility would meet the most recent West German air emissions standards, the surrounding community is becoming concerned about any additional emissions. The principal worries are emissions of heavy metals, such as cadmium and lead, and of TCDD.

Federal officials say the new facility is necessary because the volume of hazardous waste is increasing. Under current West German law, all volatile organics have to be incinerated; only inert inorganics can be landfilled. A permit for the expansion will come from the Hessen government, but the public can challenge that permit and then a special hearing would have to be held. That could well happen.

Local environmental groups are a fairly recent phenomenon in West Germany, and most do not have the expertise or resources of comparable U.S. organizations. However, because enforcement of environmental laws passed by

fuel to the continuing controversy over whether there is sufficient treatment capacity to handle all the wastes generated. Despite efforts by industry to control the volume of wastes, most analysts of the hazardous waste issue see amounts increasing over the next decade. EPA's Denit says that currently only about 100 hazardous waste incinerators are operating in the U.S., both private and commercial, with operating permits pending for another 100.

Many liquid organic chemical wastes are currently burned in large cement kiln incinerators, which do not face the same regulatory restrictions as do commercial waste incinerators. These operations, which burn the liquid wastes as blended fuel supplements do so under a provision that exempts this kind of "recycling" of material from the waste regulations. In the near future, these kilns will have to meet the same emissions standards for hydrogen chloride, hydrocarbons, and particulates as do other hazardous waste incinerators.

Landfills represent another problem. Because of tough RCRA permit requirements, most landfills that took hazardous wastes closed sev-

C&EN staff photo

Denmark's Kommunikemi incinerator to destroy 50,000 tons of waste yearly

the West German government are handled almost exclusively at the state level and because of the past history of close relationships between West German industry and the government, suspicion is growing as to whether the state's decisions are always in the public's best interest.

Just to the west of Hessen is the state of North Rhine-Westphalia, the most heavily industrialized state in West Germany and the site of Bayer's headquarters and largest facility in the town of Leverkusen. Bayer, like the HIM site, is faced with expanding volumes of waste, a result in part of the elimination of the option to burn hazardous wastes at sea and of pressure to halt the export of wastes to East Germany or the U.K.

Because North Rhine-Westphalia as a whole generates a large amount of waste and has little space to put it, using landfilling exclusively is not really an option for Bayer. Despite this situation, company officials say the integrity of landfills has been improved since the 1960s. Clay barriers and thick plastic liners, as well as goundwater monitoring, are now required for such facilities. But the landfills have been in use for a long time, and the older waste is still being slowly leached into the Rhine River above the town. So Bayer is expanding its incineration capacity at Leverkusen. That expansion will permit it to burn nearly 100,000 tons of waste per year, some of which would include hazardous waste from the municipality.

Bayer's plans to expand its incineration capacity have not drawn much environmental opposition from the local community, which largely depends on the company for work and has lived comfortably with this plant for more than 100 years. The community may also have been reassured by pronouncements by local officials—who have been monitoring for health effects for many years—who say they have not seen any adverse effects caused by either the landfills or the increasing levels of incineration.

The opposition has come from national environmental organizations who, like their Swiss counterparts, believe that source reduction is the solution to hazardous waste problems and that industry is not doing enough to achieve that goal.

One of the most sophisticated waste handling systems is in Denmark, where the basic philosophy is that if safe disposal of hazardous materials is made cheap enough then companies or individuals won't throw them away unsafely. The country has established a nationwide system for collecting hazardous wastes, both from industry and cities, that is all transported and disposed of in one place—the town of Nyborg. The incinerator and landfill complex located there, called Kommunekemi, was founded in 1971 and is currently handling more than 100 million tons of waste annually. The government is planning to expand its capacity and is facing the same environmental opposition expressed in Switzerland and West Germany.

Basically the argument against expansion is the same. Organizations concerned about the long-term impacts of new incinerators and expanded landfill capacity believe a lot more could be done in waste reduction. In Denmark especially, the government's efforts to keep disposal costs low remove any incentive for waste generators to reduce hazardous wastes. There are also complaints about the landfill, which the government openly admits leaches pollutants into the sea where dilution is expected to counter any toxicity. There are, though, reports of fish kills and some area waters depleted of oxygen.

The town of Nyborg, interestingly, does not seem bothered by its being the center for all hazardous waste in the entire nation of Denmark. In fact, it seems a little proud of the distinction. For its trouble, the city does get steam heat from the incinerator for its public buildings, and the unit also generates electricity.

Europeans do not have the institutions in place to challenge hazardous waste management decisions once they have been made by their governments. They also seem more willing to accept such decisions as being in the nation's best interest, without the legal acrimony so often present in U.S. waste management issues. But discontent is growing, and the increased prominence of groups like the Green Party are forcing people to look more closely at how waste decisions are made. Both industry leaders and government officials alike foresee more difficulty in handling hazardous waste problems.

eral years ago. Although the few commercial facilities left have large capacities, EPA doesn't know how long they will last. Considering the difficulty that new facilities, either landfills or incinerators, have in getting permission from local communities for construction, new commercial treatment facilities will come on line very slowly, if at all.

As a result of the RCRA rules, and the need to reduce emissions because of the Superfund toxic emissions inventory, most companies are searching for new processes and new technologies for the treatment of waste, says Robert F. Olfenbuttel, director of waste minimization at Battelle Columbus Laboratories. "Everyone now wants to optimize their process operations to be sure they get wastes that can be recycled or try to take the unused products and recycle them back into the production stream," he says. One of the results of this are dozens of small technology firms trying to break into the market with new methods for reducing hazardous wastes. Because more than 90% of the wastes generated are treated at plant sites, many of these new treatment technologies are add-ons to existing equipment.

Product sales to exceed service revenues by 2000

$ Millions	1977	1988	1993	2000	Average annual growth 1977–88	Average annual growth 1988–93
HAZARDOUS WASTE PRODUCTS	$120	$3500	$ 9,300	$23,000	35.9%	21.6%
Treatment chemicals	40	520	2,550	9,000	26.3	37.4
Incineration equipment	40	1600	4,000	8,500	39.8	20.1
Processing equipment	10	340	1,020	2,700	37.8	24.6
Analytical instruments	25	390	700	1,100	28.4	12.4
Other products	5	650	1,030	1,700	55.7	9.6
HAZARDOUS WASTE SERVICES	385	6200	10,900	20,000	28.7	11.9
Transportation	185	2560	3,770	4,700	27.0	8.0
Consulting/engineering	5	700	1,400	3,500	56.7	14.9
Remediation/cleanup	neg	645	1,290	3,400	—	14.9
Incineration services	10	370	920	2,500	38.9	20.0
Analytical testing	35	610	1,070	2,300	29.7	11.9
Landfill disposal	15	605	1,370	2,000	39.9	17.8
Other services	135	710	1,080	1,600	16.3	8.8
TOTAL	$505	$9700	$20,200	$43,000	30.8%	15.8%

neg = negligible. Source: Freedonia Group

One of the reasons for developing add-ons is that most production processes are unique and require custom treatment designs. When waste management specialty companies, such as Chemical Waste Management of Oak Brook, Ill., go into a plant, they have to be flexible. "One of the key issues in our business is variability," says George Vander Velde, Chemical Waste's vice president for science and technology. "Waste streams vary a lot from plant to plant, and even within a company. Wastes also vary from day to day for a lot of reasons." One new system Chemical Waste is developing as an add-on to existing plants is an evaporator for wastewater. This evaporator, according to Vander Velde, uses a proprietary catalyst for oxidizing organics directly to carbon dioxide and very pure water. Any hydrochloric acid, a frequent by-product of wastewater treatments, can be removed easily by alkaline scrubbers.

Olfenbuttel says separation technology is becoming key to reducing wastes. By more efficient removal of the pollutants from water streams, companies can reduce their volume of wastes. Battelle is testing an electromembrane-technology process for high-yield separation and concentration of hazardous wastes.

Traditional specialty chemicals companies that offer treatment chemicals and waste management services, like Nalco Chemical in Naperville, Ill., are widening the scope of their products. "We are looking at better ways to control the separation process," says Nalco's Ron Schild, marketing manager for the company's basic industry group. "We are trying to automate the process to get the optimum sludge dryness, the clarity of the water, and [to] minimize the amount of chemical used. We've introduced some new automation schemes this year that will save money and help the minimization of sludge."

Schild believes the treatment industry is moving rapidly into the area Nalco calls bioengineering. "Biological treatment has been around for many years," he says, "because microorganisms can successfully metabolize a lot of substances." His company is expending great effort to find naturally occurring organisms—not "create" new organisms by genetic engineering or gene splicing—that can degrade common hazardous waste chemicals such as phenols and polychlorinated biphenyls. "This treatment technology has improved a lot in recent years, to the point where EPA recognizes what these organisms can do in terms of bioaugmentation of existing processes or even remediation of waste sites," Schild adds.

Nonetheless, this type of treatment will only provide some of the answers. Although biotreatment prevents emissions of hazardous pollutants and eliminates waste, it does so after the fact. George Muhlbach, head of the environmental programs at Ciba-Geigy in Wilmington, says the future will be more toward specific changes in the process itself and less end-of-pipe treatments. "In water, for example, waste treatments placed at the end of the stream will be looked on more as a polishing step. Most of the waste reduction will be done with additional in-process changes and by changing the chemical used," Muhlbach says. He emphasizes that he does not limit the changes to just hazardous wastes. "We are trying to minimize all wastes. We have specific programs for our research and development people to address the whole process from the point of view of reducing the waste stream," he adds.

There is a recognized hierarchy for managing waste reduction. The first thing a company can do is improve housekeeping. Following that is to substitute less hazardous materials for ones currently used. Then methods for recycling and reusing materials are developed. Then comes modification of the process to reduce waste. The last option is simply disposal.

Monsanto's Mullins says, "I think we've reached the point now where virtually everybody in the industry is sensitive to that hierarchy of desirability of pollution prevention. Institutionalizing that, and getting it moved all the way back to the research and the manufacturing ends, is the real challenge."

Success stories of chemical plants getting dramatic reductions in hazardous waste by making what seem to be obvious improvements are becoming almost common. One example cited by Mullins at a recent Congressional hearing on waste reduction is typical. Monsanto's Port Plastics plant near Cincinnati managed to reduce loss of a particular resin more than 75% by using better gasket materials, improving maintenance procedures, and get-

ting unused resin to polymerize thus rendering it nonhazardous. Mullins says the plant saves $200,000 yearly in reduced raw material and waste management costs. Such reductions are very process-specific and consequently will make significant waste reduction look like a very slow process.

EPA assumes that, eventually, one third of all hazardous waste generated can be eliminated before it is produced. Among the programs the agency has under way to encourage waste reduction is a national computer clearinghouse, which provides waste reduction information to those interested.

Overshadowing all the corporate efforts on hazardous waste reduction and waste management is the Superfund law, particularly a provision that sets strict and several liability on anyone involved at a site. That is, EPA can hold any company liable for cost of the entire cleanup of an abandoned site regardless of the amount of wastes that that company placed into the site.

"This makes corporate management reconsider any type of waste management and forces them to think more about waste reduction," says Hirschhorn. Monsanto's Mullins agrees that this liability has changed attitudes. "There is a new awareness of the real economics, of the real liabilities of hazardous waste because we now have plant managers signing checks to pay for cleanups. The costs in dollars are appearing on the bottom line."

That is one of the main reasons why more than 90% of hazardous wastes are treated on the same site they are generated—to avoid the liability that comes with having to put that waste somewhere else. It is also a reason why chemical companies and other waste generators are becoming concerned with wastes that are not even currently regulated as hazardous. OTA's Hirschhorn says, "People who are disposing of waste today that is hazardous but not regulated under RCRA are going to get nailed under Superfund. It makes no difference if that waste is regulated today. A very high fraction of truly hazardous waste could be going to regular landfills perfectly legally. All of these will become, eventually, Superfund sites." Mullins concurs. "There is a real concern about the liabilities of disposing of waste not now regulated as hazardous," he says. "This is precisely the situation we had before Superfund. You could dispose of the wastes legally, but you were amassing this enormous liability."

The so-called Title III toxic emissions inventory required under Superfund is also having a major impact on waste management decisions. The inventory is a compilation of environmental release data on more than 325 chemicals that Congress listed as toxic under the 1986 amendments to the Superfund law. Virtually all of the data are made available to the public.

"I'd say the past year and a half has been very much a transition period in which we have been establishing new programs with a focus on the broader aspects of all wastes to all media, whereas we had just finished institutionalizing a focus on solid hazardous waste," Mullins says. Because the emissions inventory covers all releases of hazardous chemicals, it may be only a matter of time before all of the

Waste volume will grow despite reduction efforts

Millions of tons	1977	1988	1993	2000	Average annual growth 1977–88	Average annual growth 1988–93
TOTAL	131	291	380	510	7.5%	5.5%
BY TYPE OF WASTE						
Heavy metals	51	114	149	196	7.6	5.5
Organic chemicals	42	100	132	180	8.2	5.7
Petroleum derived	16	33	44	60	6.8	5.9
Inorganic chemicals	17	35	43	55	6.8	4.2
Other hazardous waste	5	9	13	19	5.5	7.6
BY METHOD OF DISPOSAL						
Landfill/surface impound	12	200	225	165	29.1	2.4
Treatment/stabilization	2	13	50	150	18.5	30.9
Incineration	neg	15	35	95	—	18.5
Resource recovery	2	12	30	75	17.7	20.1
Deep-well injection	5	14	15	10	9.8	1.4
Illegal disposal	110	35	20	5	−9.9	−10.6
Other methods	neg	2	5	10	—	20.1

neg = negligible. Source: Freedonia Group

Chemical Waste Management photo

Chemical Waste's hazardous waste landfill at Emelle, Ala., is U.S.'s largest

chemicals are listed by somebody as hazardous wastes, and therefore have to be controlled as such. Mullins hopes the industry will not just have a knee-jerk reaction to this and treat these materials exclusively with end-of-the-pipe controls. "The big problem is to think first about source reduction and then about treatment," he says.

One very visible result of all the waste treatment requirements of RCRA and of the testing and remediation activities demanded by Superfund is a burgeoning hazardous waste service industry. And industry analysts expect that growth to continue at a rapid pace. William P. Weizer, vice president of the chemicals and plastics division of Freedonia Group, a consulting firm in Cleveland, has just finished an in-depth study of the prospects for the waste industry. It concludes that the industry will be a $20 billion service and product business by 1993. "There are more than 350 companies engaged in hazardous waste management," Weizer says. "Of these, the top 30 firms generate about 70% of the aggregate revenues."

Although these companies are expected to show rapid growth in revenues over the next 10 years, there are some adjustments expected in the industry as a whole. "We are starting to see some rationalization in the industry," says Michael E. Hoffman, industry analyst for the Salomon Brothers investment firm, "particularly in the remediation area."

"Early on in Superfund, just about anybody who could operate a backhoe was sending in bids on those projects. Now the financial hurdles are starting to keep some players out because they cannot provide the bonding required to bid on the federal projects," he says.

Robert Buhr at Moody's Investors Service sees much the same situation. "A problem for smaller companies was the anticipation of large amounts of Superfund work," Buhr says. "But EPA got bogged down and the revenues haven't come along as anticipated."

One of the things that will happen over the next several years in the treatment and disposal area will be some consolidation by larger companies. "There are a lot of little guys out there who do all right in their own regions, but they've got financial constraints and aren't able to grow. If you have an objective to be a national player, you need the economy of scale," Weizer says, adding that the push for improved technologies is the reason for mergers. "The main reason for consolidation is the technology, the money required for research and development, and commercialization of the product." Because of the consolidation of companies in the next few years, Weizer expects that the 70% of the revenues now collected by 30% of the companies will become 80% of total revenues by 2000.

From a different point of view, Moody's Buhr says that anyone trying to buy a waste management company will have to be careful. Some of them, those that are doing well, are going to go at premium prices. Others will not. "It is going to be a company-by-company situation," Buhr adds. "But the premium is not unreasonable because of the tremendous potential for growth."

The growth in treatment and incineration has been driven by federal regulations. Putting hazardous wastes in landfills is being discouraged because of the risks associated with soil and groundwater contamination, as Freedonia Group notes. Despite this, the group says the land methods of disposal, including landfills, surface impoundments, and deep-well injection, will continue to dominate the market over the next decade. This is because certain hazardous wastes, such as heavy metals and radioactive materials, are incompatible with such alternatives as pretreatment and resource recovery. These are the same materials that represent an increasing portion of hazardous waste as the government increases the number and kinds of wastes being regulated.

Concerns about too little or too much treatment capacity for hazardous wastes are discounted by industry analysts. Weizer says there is going to be enough landfill capacity but that it will get more expensive to dispose of wastes this way as time goes on. "They won't be as easy to find or as accessible as they have been in the past. They

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might be farther out, and transportation costs will be higher." Salomon's Hoffman concurs, "If you take out the wastes that are subject to the RCRA land ban, and don't significantly increase the volume of those wastes in the pretreatment process, then there is probably 35 to 50 years of available landfill capacity." Weizer believes that some companies crying the loudest about landfill closings and insufficient capacity may just be trying to get people to think there is a crisis in order to justify charging higher prices.

Hoffman says that a number of persons argue that there is going to be an overcapacity in incineration. As EPA continues to issue new permits, commercial operations might suffer from a glut of incinerators. "We strongly believe this is wrong," he adds. "The incineration business shows signs of real resilience in the face of all the [public] opposition. And, there are not a lot of commercial solid waste incinerators."

Estimates are that about one fifth of all the increased hazardous waste volume that will result from new regulations will be incinerated. Hoffman believes that liquid incineration has reached its capacity, partly because a lot of liquids can be burned in cement kilns and industrial boilers and be classified as recycled waste. When these facilities have to meet the same environmental standards as regular incinerators, most will stop using blended wastes.

The cleanup, disposal, and minimization of hazardous wastes will continue to be driven by government regulations. New laws are likely to increase the volume and number of wastes being regulated and the laws are likely to remain complicated. Vander Velde says his salespeople have to spend a lot of time just explaining to people how to comply with the existing law. More regulations will not change that. Yet, chemical waste treatment is an exciting business to be in at this time, he says, with so many things going on.

Still, the public's concerns, as voiced by Congress and environmental activist groups, are going to carry a lot of weight in determining how the chemical industry and its wastes are managed for a long time to come. □

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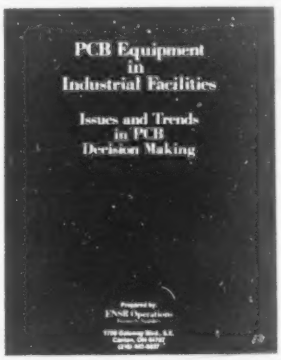

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